

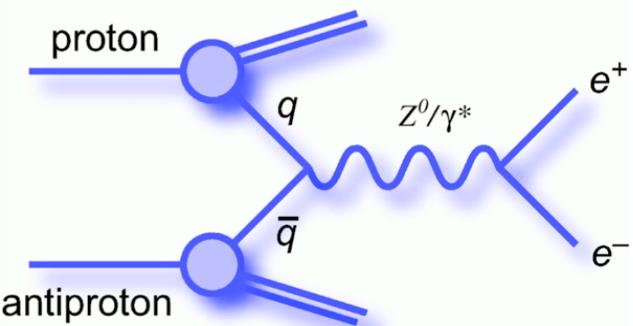
Measurement of the Forward- Backward Charge Asymmetry in $p\bar{p} \rightarrow Z/\gamma^* \rightarrow ee$ at DØ

Hang Yin (FermiLab)

DØ Collaboration

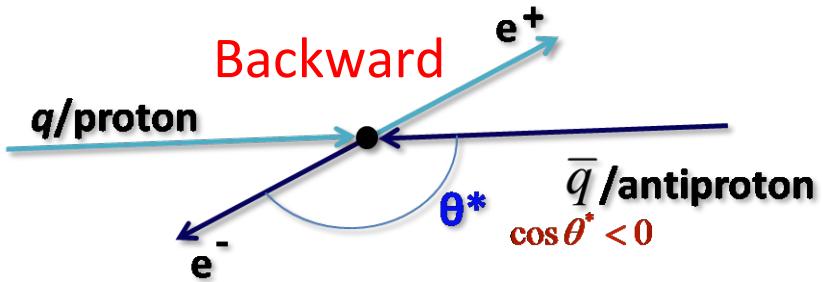
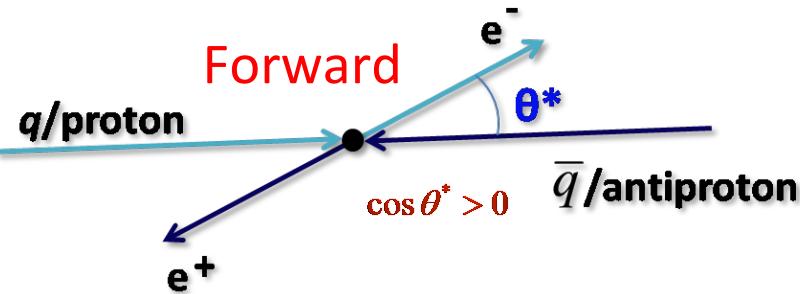
DIS 2011
13th April, 2011

Introduction



- Vector and axial-vector couplings of Z boson to fermion: $g_V^f = I_3^f - 2Q_f \sin^2 \theta_W$ and $g_A^f = I_3^f$

The presence of both vector and axial vector couplings gives rise to non-zero A_{FB} .

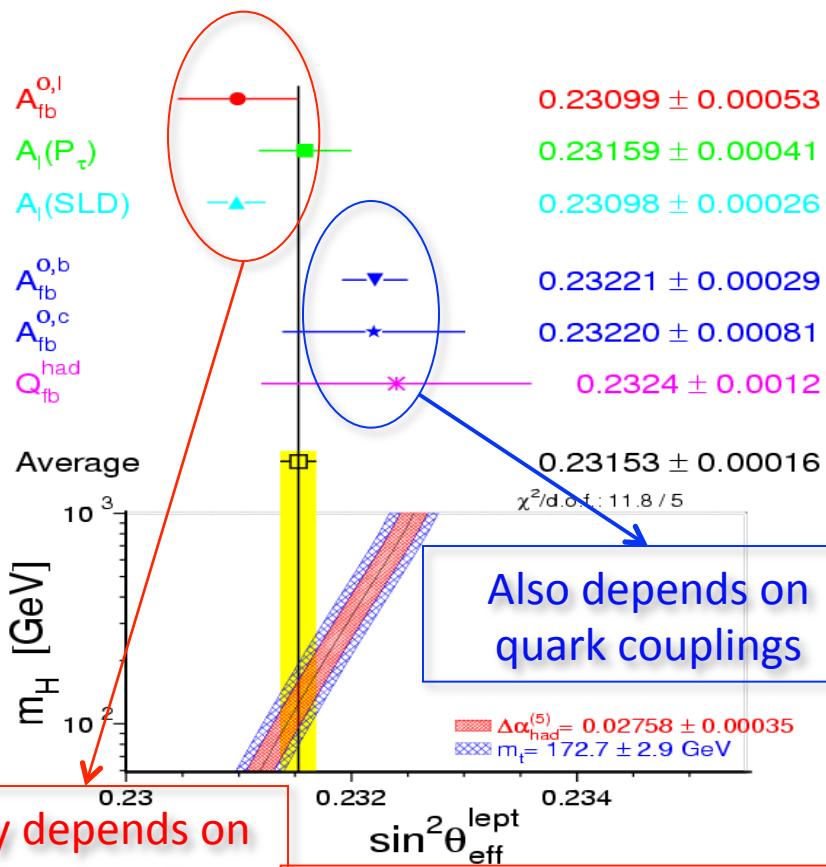


- The differential cross section: $\frac{d\sigma}{d\cos \theta^*} = A(1 + \cos^2 \theta^*) + B \cos \theta^*$

- Forward-backward asymmetry :
 - σ_F : the cross section for events with $\cos \theta^* > 0$
 - σ_B : the cross section for events with $\cos \theta^* < 0$

$\sin^2\theta_W^{\text{eff}}$

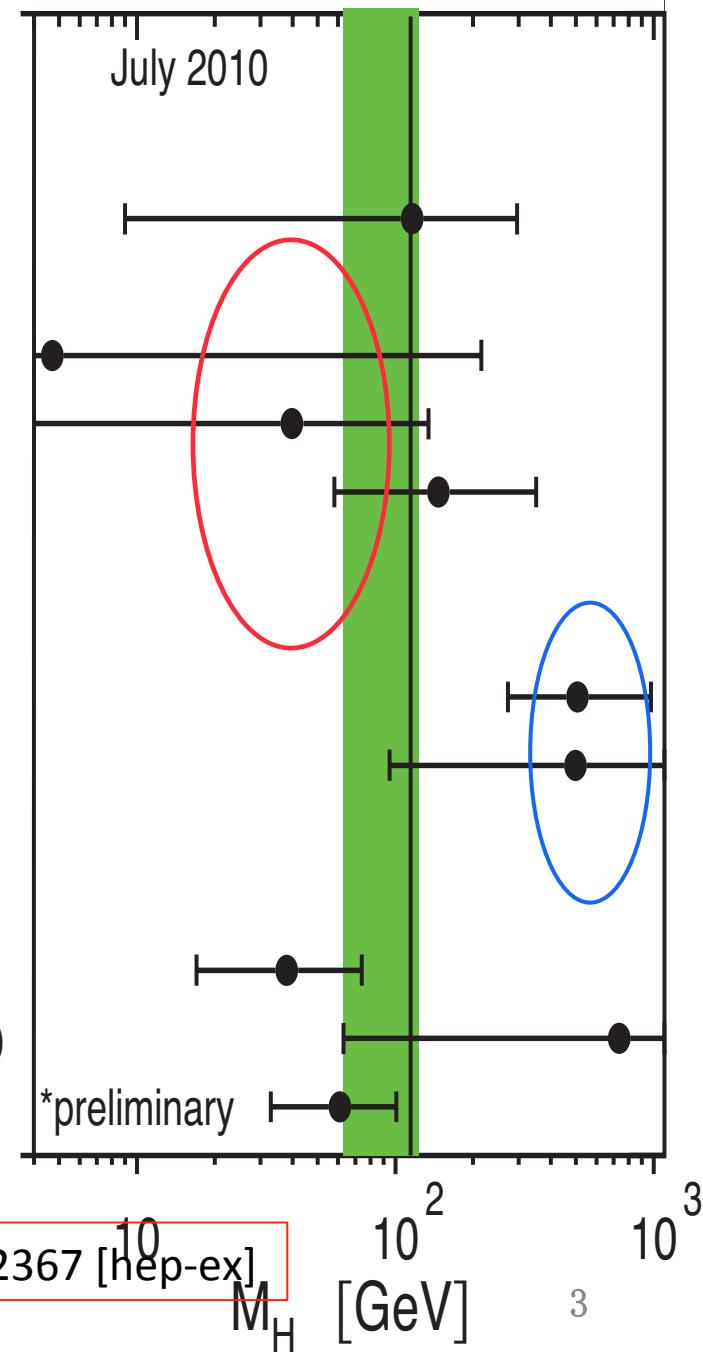
- A_{FB} is sensitive to $\sin^2\theta_W^{\text{eff}}$
- Given α , G_f , and M_Z , we can use $\sin^2\theta_W^{\text{eff}}$ to constraint higgs mass



April 13th, 2011

CERN-PH-EP/2010-095 and arXiv:1012.2367 [hep-ex]

DIS 2011, Hang Yin



$\sin^2\theta_W^{\text{eff}}(\text{cont.})$

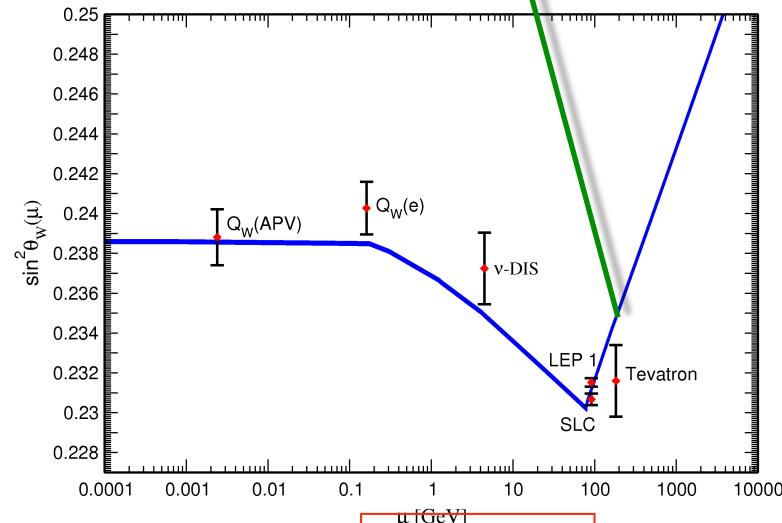
Measurement	Fit	$ O^{\text{meas}} - O^{\text{fit}} /\sigma^{\text{meas}}$
$\Delta\alpha_{\text{had}}^{(5)}(m_Z)$	0.02758 ± 0.00035	0.02767
$m_Z \text{ [GeV]}$	91.1875 ± 0.0021	91.1874
$\Gamma_Z \text{ [GeV]}$	2.4952 ± 0.0023	2.4959
$\sigma_{\text{had}}^0 \text{ [nb]}$	41.540 ± 0.037	41.478
R_I	20.767 ± 0.025	20.743
$A_{tb}^{0,I}$	0.01714 ± 0.00095	0.01643
$A_{\ell}(P_\tau)$	0.1465 ± 0.0032	0.1480
R_b	0.21629 ± 0.00066	0.21581
R_c	0.1721 ± 0.0030	0.1722
$A_{tb}^{0,b}$	0.0992 ± 0.0016	0.1038
$A_{tb}^{0,c}$	0.0707 ± 0.0035	0.0742
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
$A_{\ell}(\text{SLD})$	0.1513 ± 0.0021	0.1480
$\sin^2\theta_{\text{eff}}^{\text{lept}}(Q_{\text{fb}})$	0.2324 ± 0.0012	0.2314
$m_W \text{ [GeV]}$	80.398 ± 0.025	80.377
$\Gamma_W \text{ [GeV]}$	2.097 ± 0.048	2.092
$m_t \text{ [GeV]}$	172.6 ± 1.4	172.8

($\sin^2\theta_W^{\text{eff}}$ includes higher order corrections)

Dzero 1.1 fb^{-1} publication.
Phys. Rev. Lett. 101, 191801 (2008)

And CDF 72 pb^{-1} PRD publication

LEP and SLD most precise results are off by 3σ in opposite direction

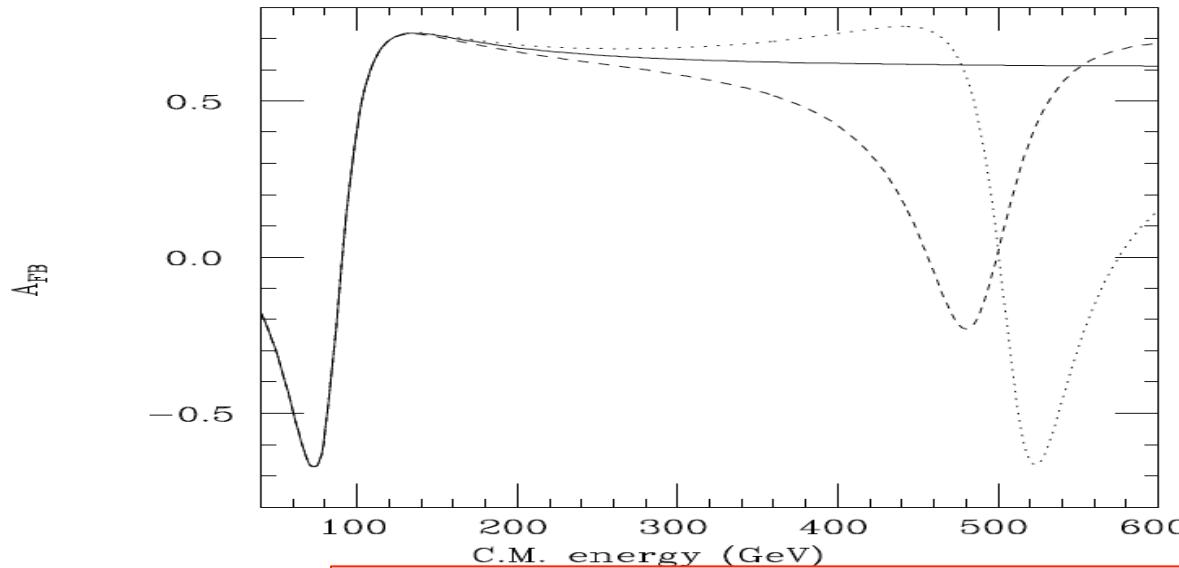


Motivation

➤ Test of Standard Model

- Forward-backward asymmetry
- Weak mixing angle
- Z to light quark couplings

➤ Sensitive to beyond SM physics



J. L. Rosner, Phys. Rev. D 54, 1078 (1996)

DØ detector

Silicon Microstrip Tracker (SMT)

Central Fiber Tracker (CFT)

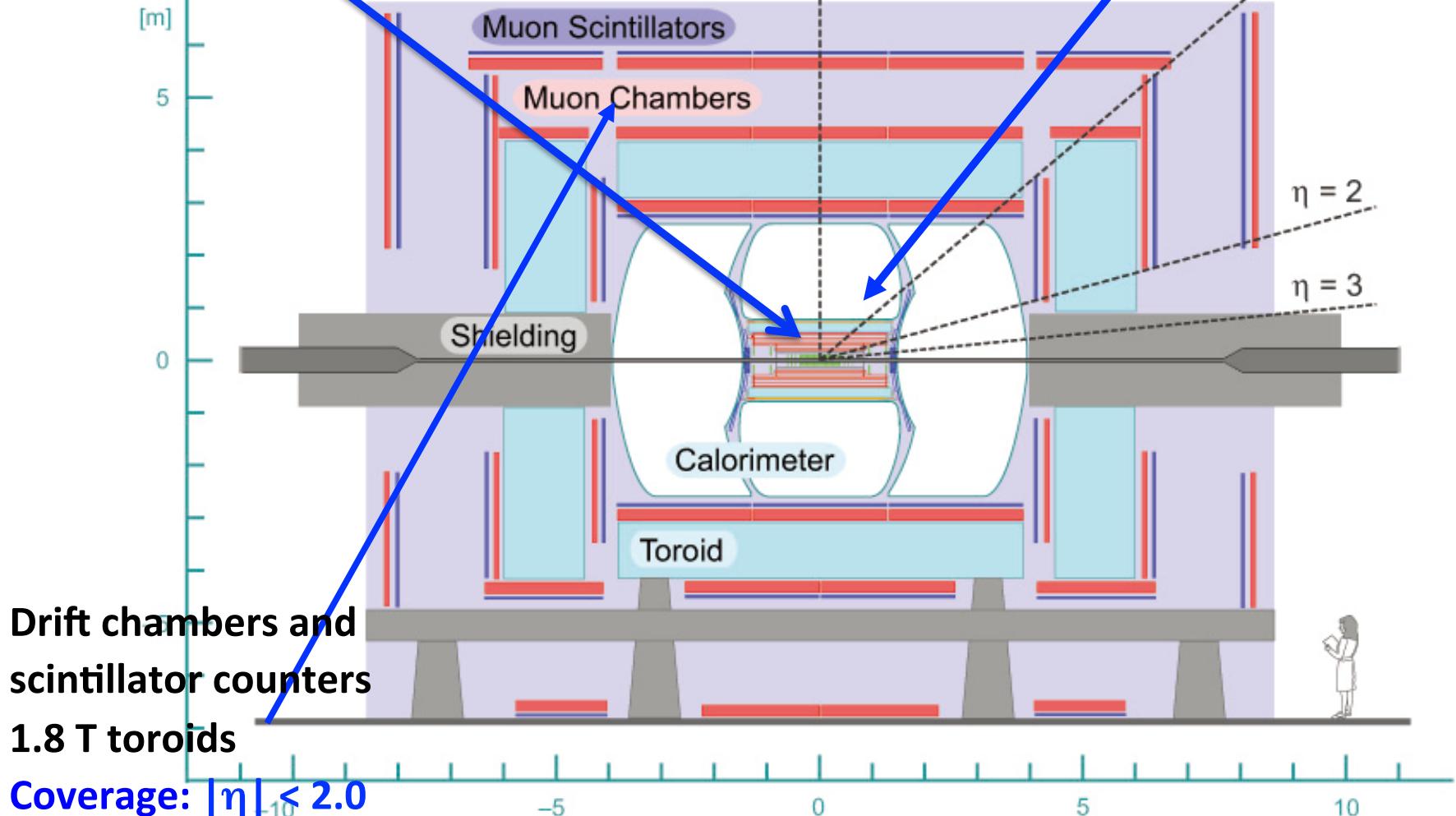
2T magnetic field

Coverage: $|\eta| < 3.0$

Uranium Liquid Argon calorimeters

Central (CC) and Endcap (EC)

Coverage: $|\eta| < 4.2$



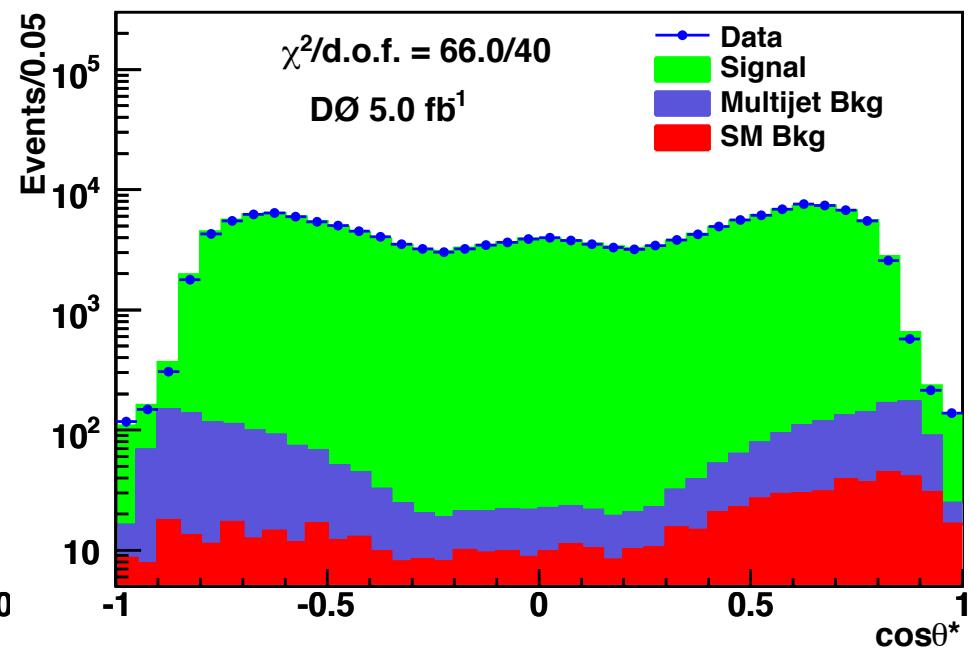
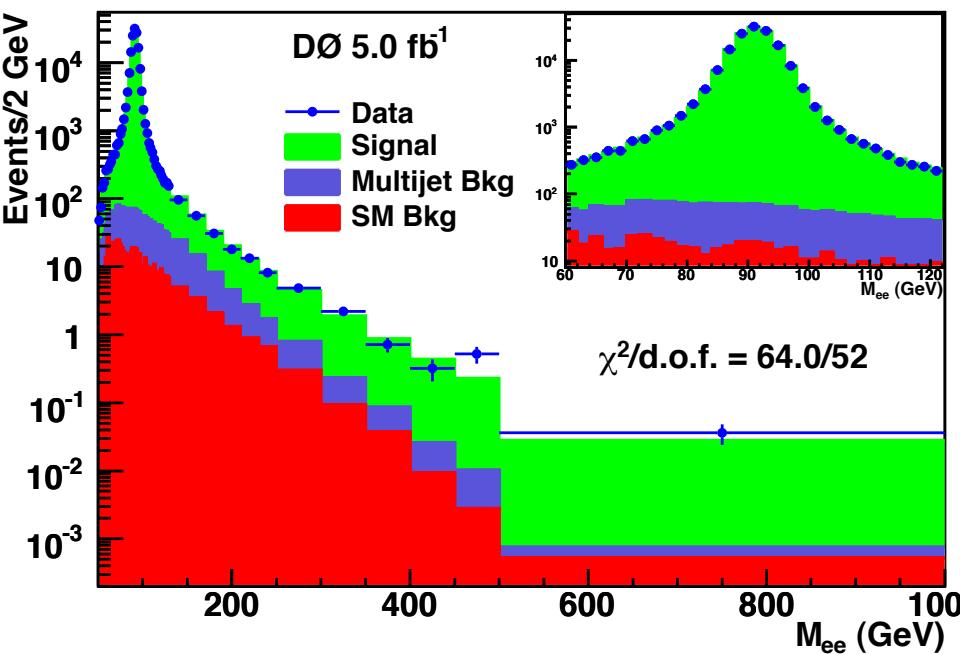
Event selections

- DØ data: $L = 5.0 \text{ fb}^{-1}$
- Two isolated electrons requirements:
 - $pT > 25 \text{ GeV}$
 - Shower shape consistent with that of an electron
- At least one electron in central calorimeter
 - Two electrons in central calorimeter (CC), require two opposite charge
 - Only one electron in CC, require CC electron must have a track match
(use the charge of CC electron to determine forward/backward event)

MC signals and backgrounds

- Signal: Pythia samples:
 - $Z/\gamma^* \rightarrow ee$ samples: passed through Geant simulation of DØ detector
 - Generator level: Z- p_T rapidity and Z Mass reweighting
 - Reconstructed level: corrected to data by applying EM smearing, efficiencies scaling
- SM backgrounds: $Z \rightarrow \tau\tau$, $W + X$, WW , WZ , $\gamma\gamma$, $t\bar{t}$
- QCD background: measured from data

Data and MC comparison



$\sin^2\theta_{\text{eff}}^{\text{lept}}$ measurement

➤ Extraction of $\sin^2\theta_{\text{eff}}^{\text{lept}}$

Compare data raw A_{FB} with predicted raw A_{FB} from MC samples with different $\sin^2\theta_W^{\text{lept}}$ input to extract the best value

➤ Measured value:

$$\sin^2\theta_{\text{eff}}^{\text{lept}} = 0.2309 \pm 0.0008 \pm 0.0006$$

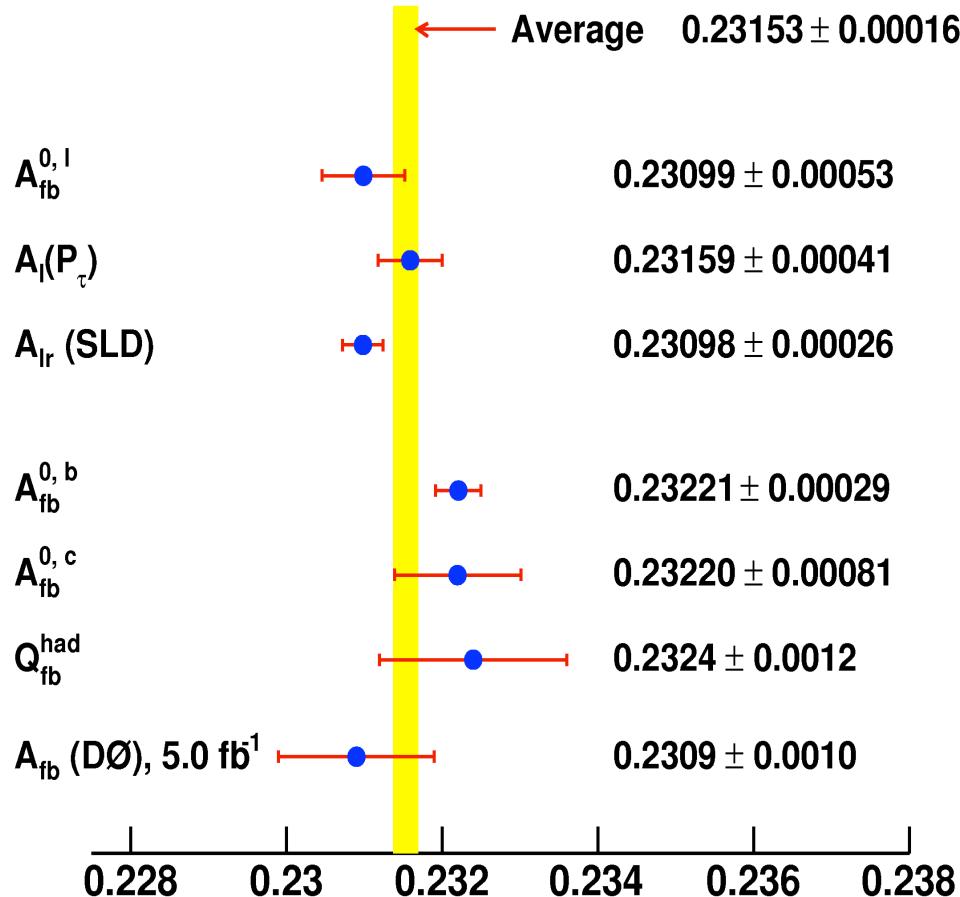
- High order correction calculated from ZGrad2 shifts measured value by **0.0005**

- **Largest systematic uncertainty** comes from PDFs

Source	$\Delta\sin^2\theta_{\text{eff}}^{\text{lept}}$
Statistical	0.00080
Systematics	0.00061
PDFs	0.00048
EM scale/reso	0.00029
MC stat.	0.00020
EMID	0.00008
Bkg. Modeling	0.00008
Charge misID	0.00004
Higher order	0.00008
Total	0.00102

$\sin^2\theta_{\text{eff}}^{\text{lept}}$ measurement (cont.)

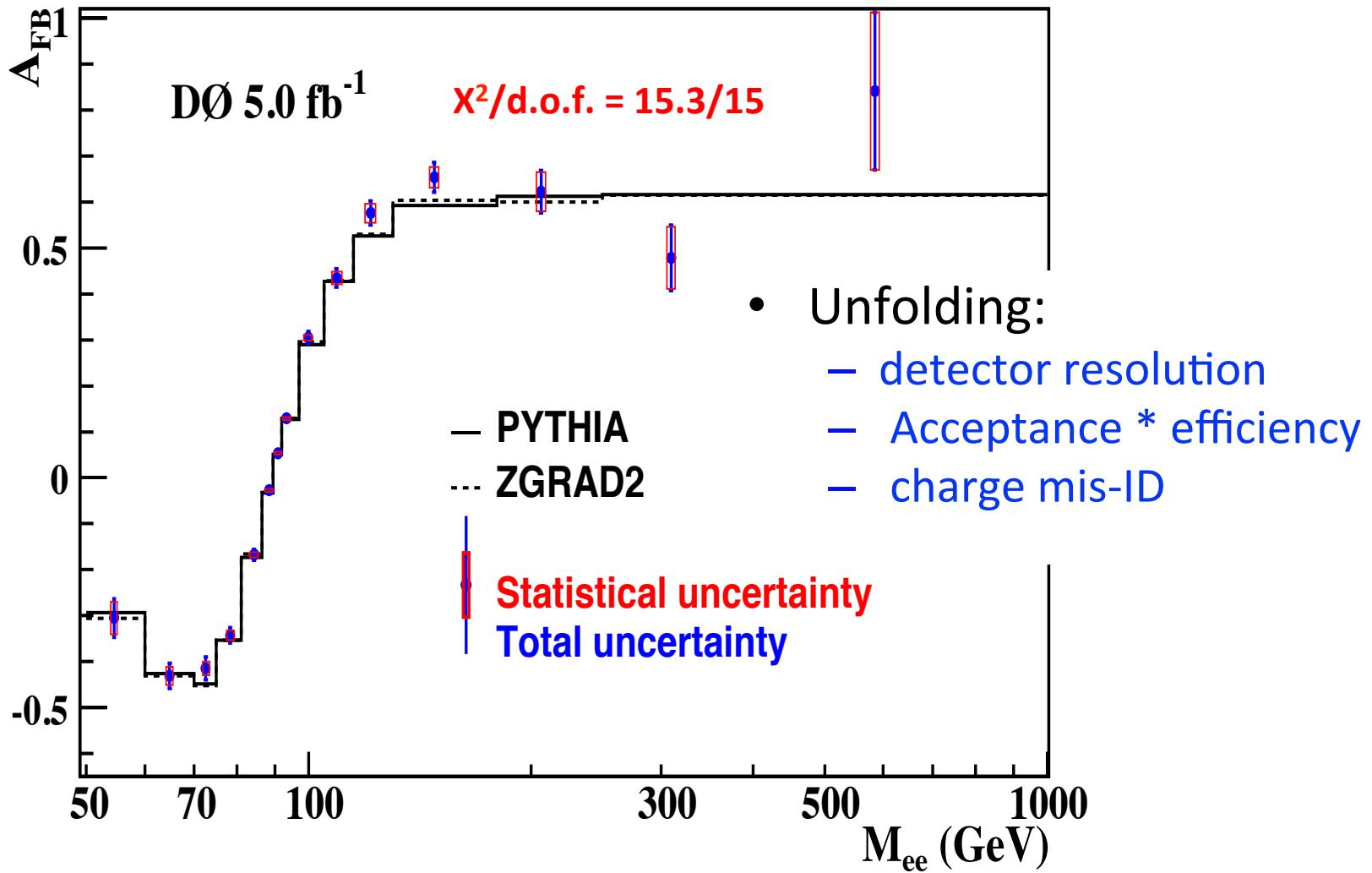
- The $\sin^2\theta_{\text{eff}}^{\text{lept}}$ predictions using ZGrad2 and Zfitter using the same input SM parameters
 - the two results are consistent with each other
- Higher order electroweak and QCD corrections have a negligible impact on DØ $\sin^2\theta_{\text{eff}}^{\text{lept}}$ measurement
 - DØ result comparable to LEP and SLD results



LEP and SLD, Phys. Rep. 427, 257 (2006)

$\sin^2\theta_{\text{eff}}^{\ell}$

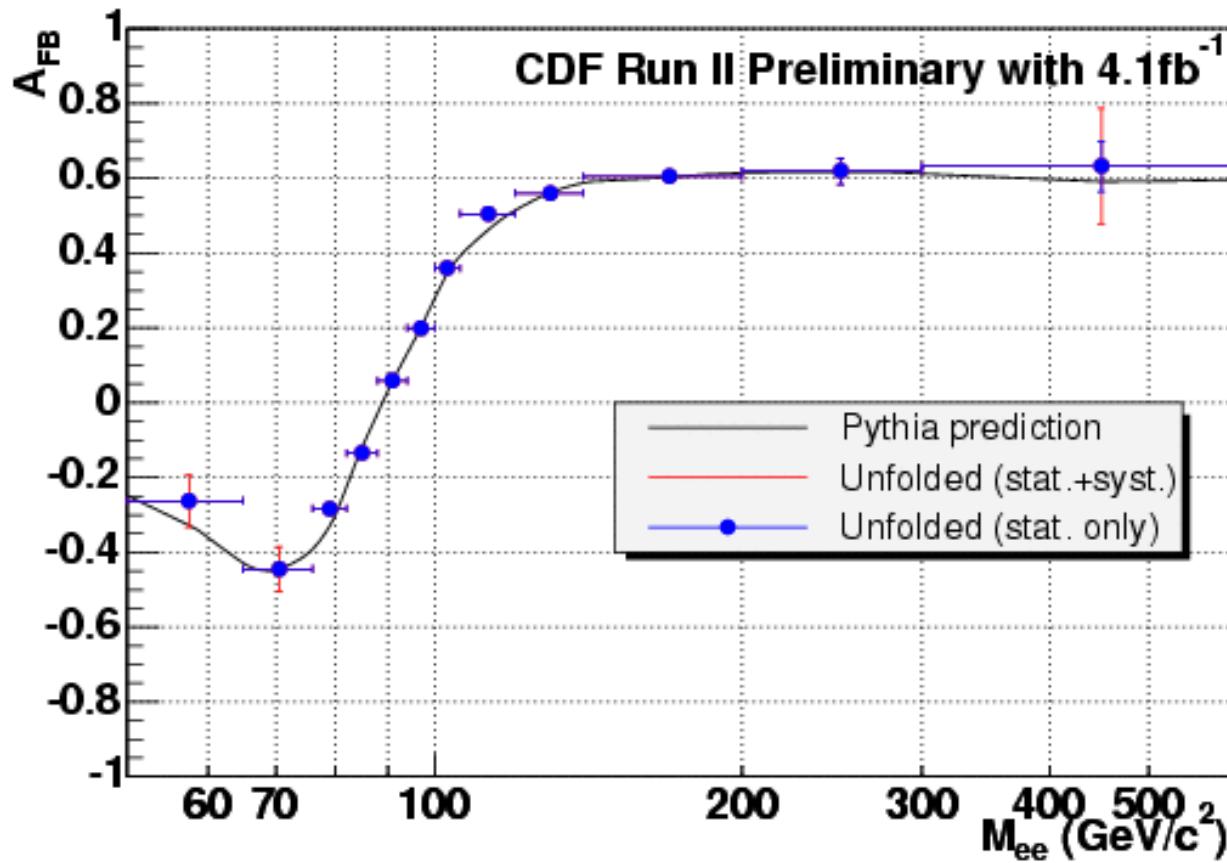
Unfolded A_{FB} measurement



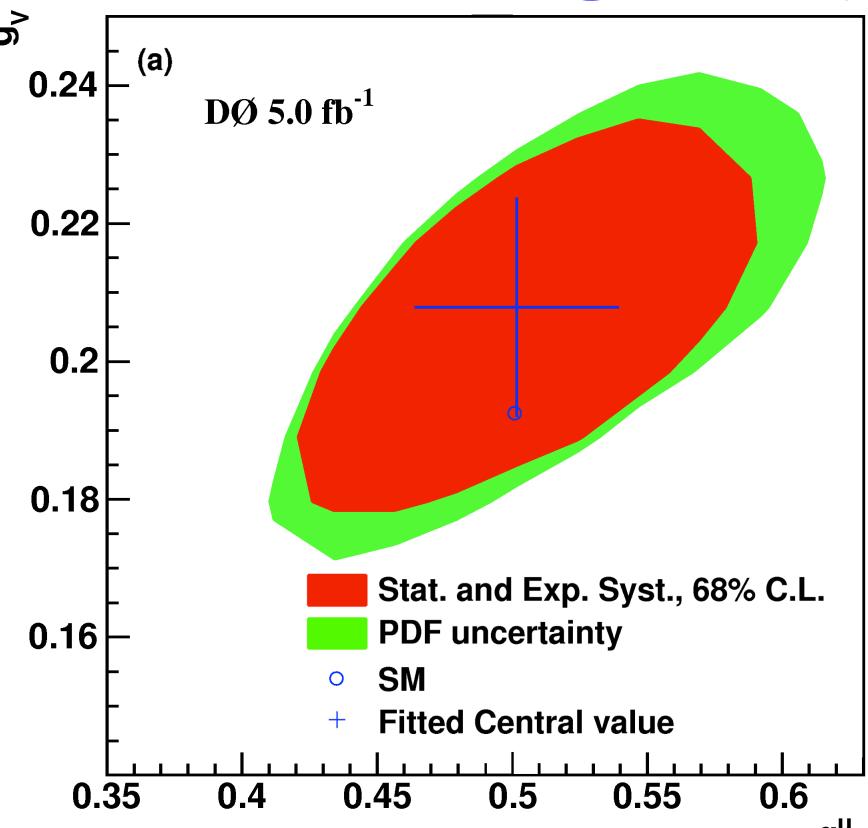


CDF results

Forward-Backward Asymmetry, A_{FB}



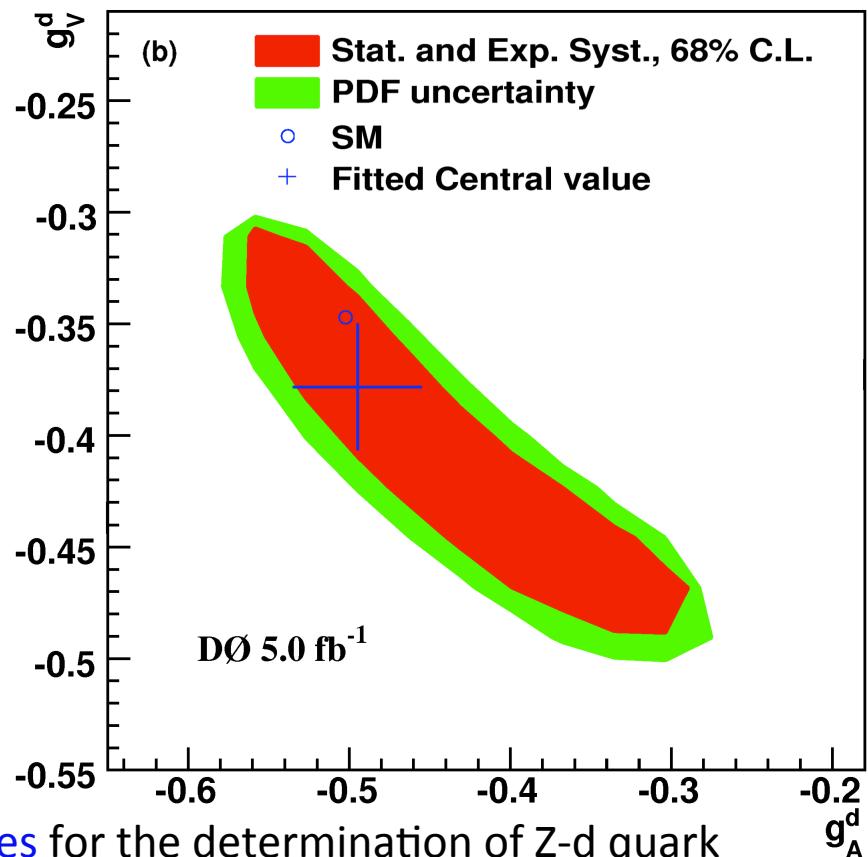
Z to light quark couplings



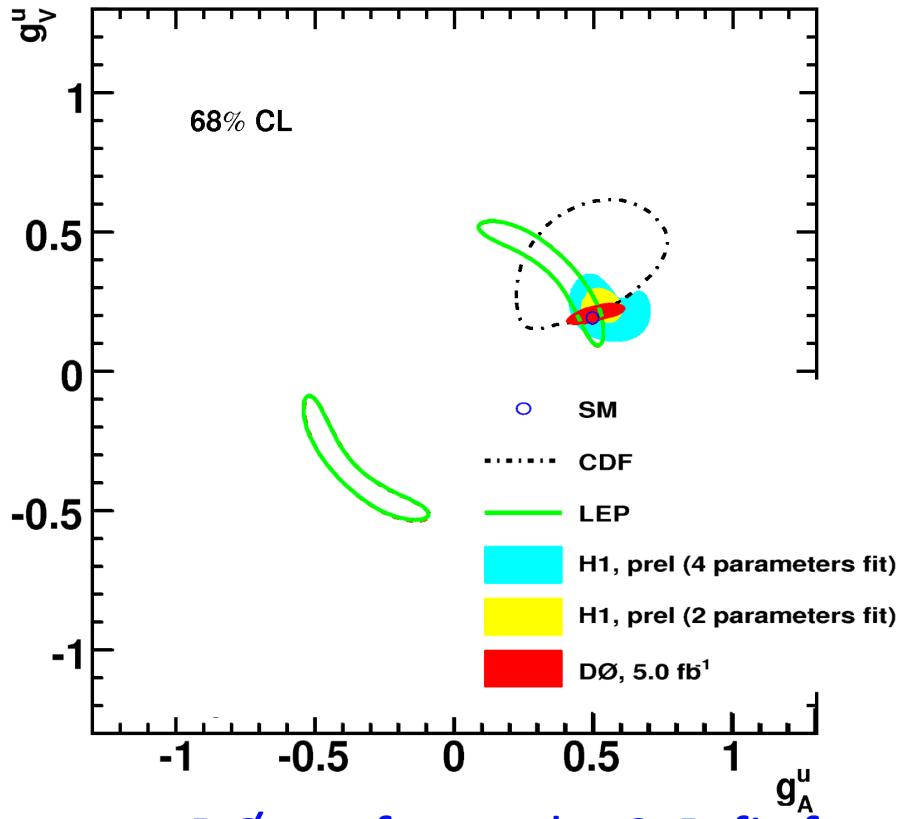
Fix Z-u quark couplings to SM values for the determination of Z-d quark couplings, and vice-versa

Fix Z-lepton couplings to SM values.

Fix weak mixing angle to world average (0.23153)

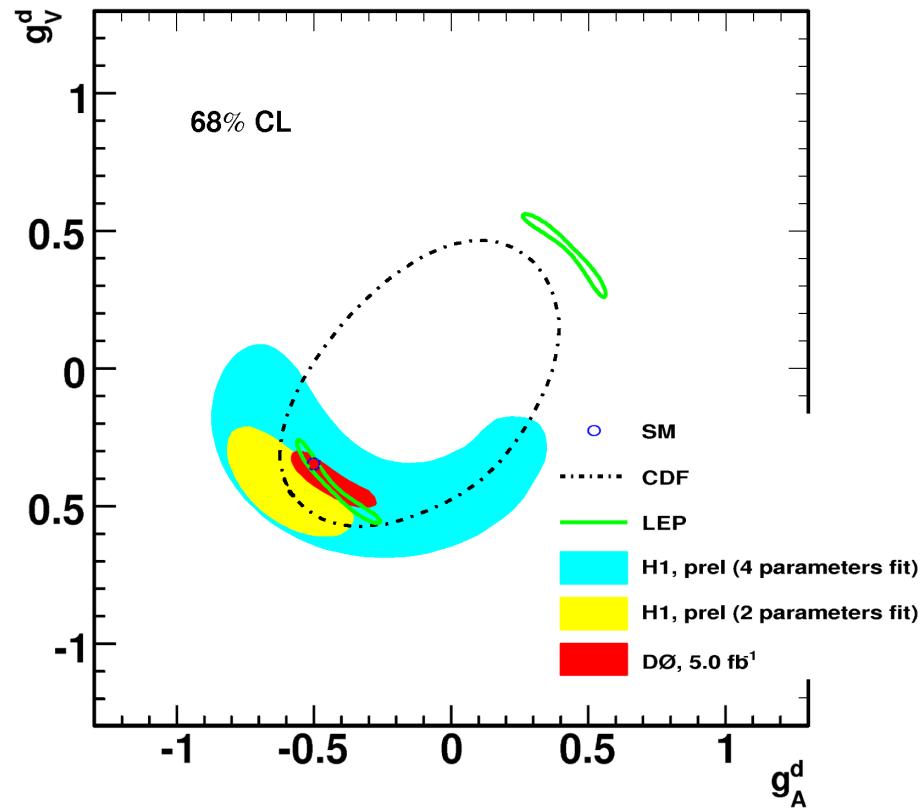


Z to light quark couplings



DØ performed a 2-D fit for u/d quark separately.

The others results are 4-D fit.



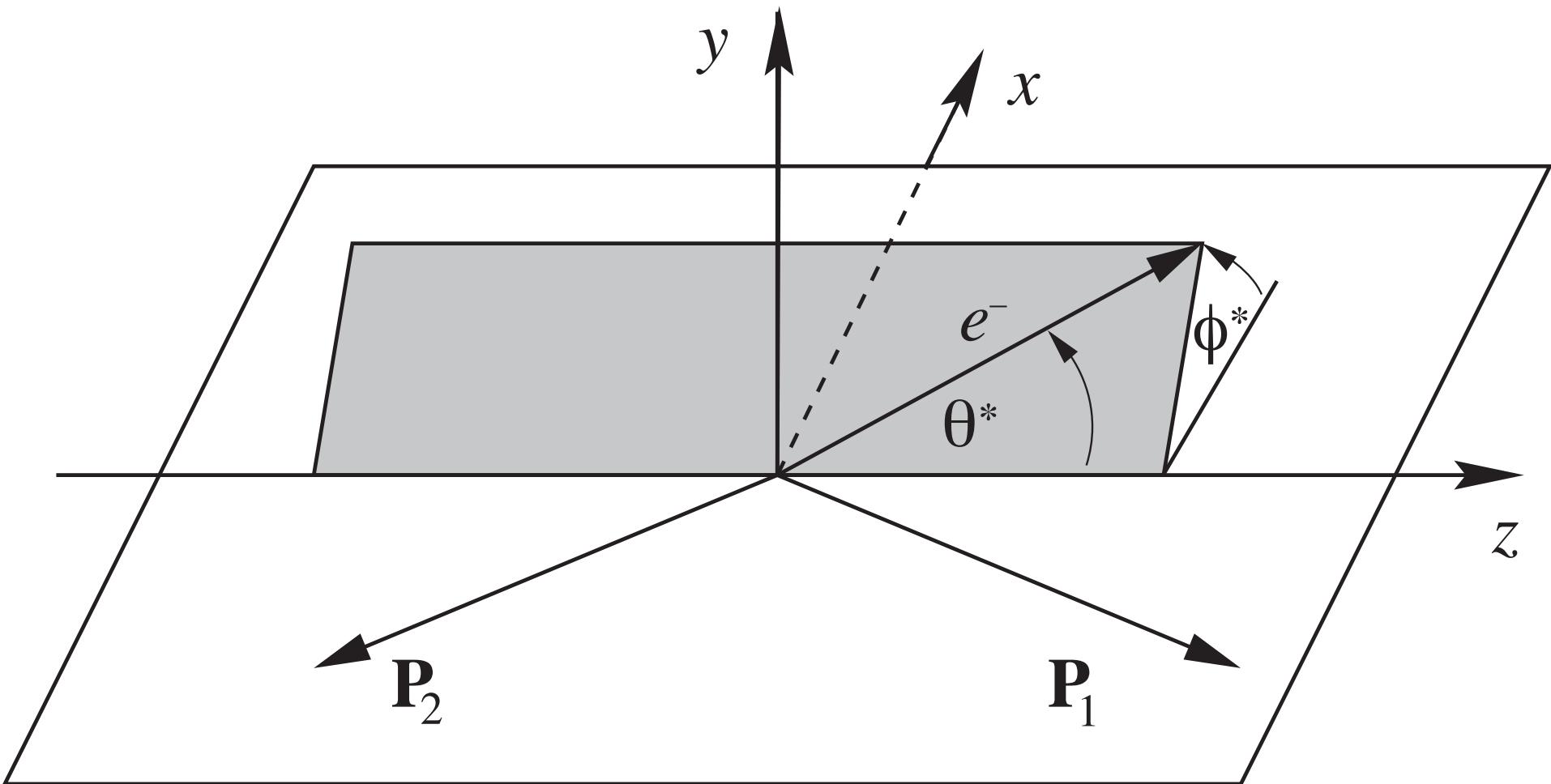
- CDF, Phys. Rev. D **71** 052002 (2005)
- LEP and SLD, Phys. Rep. **427**, 257 (2006)
- H1, Phys. Lett. B **632** (2006)
- H1prelim-10-042 (2010)

Summary

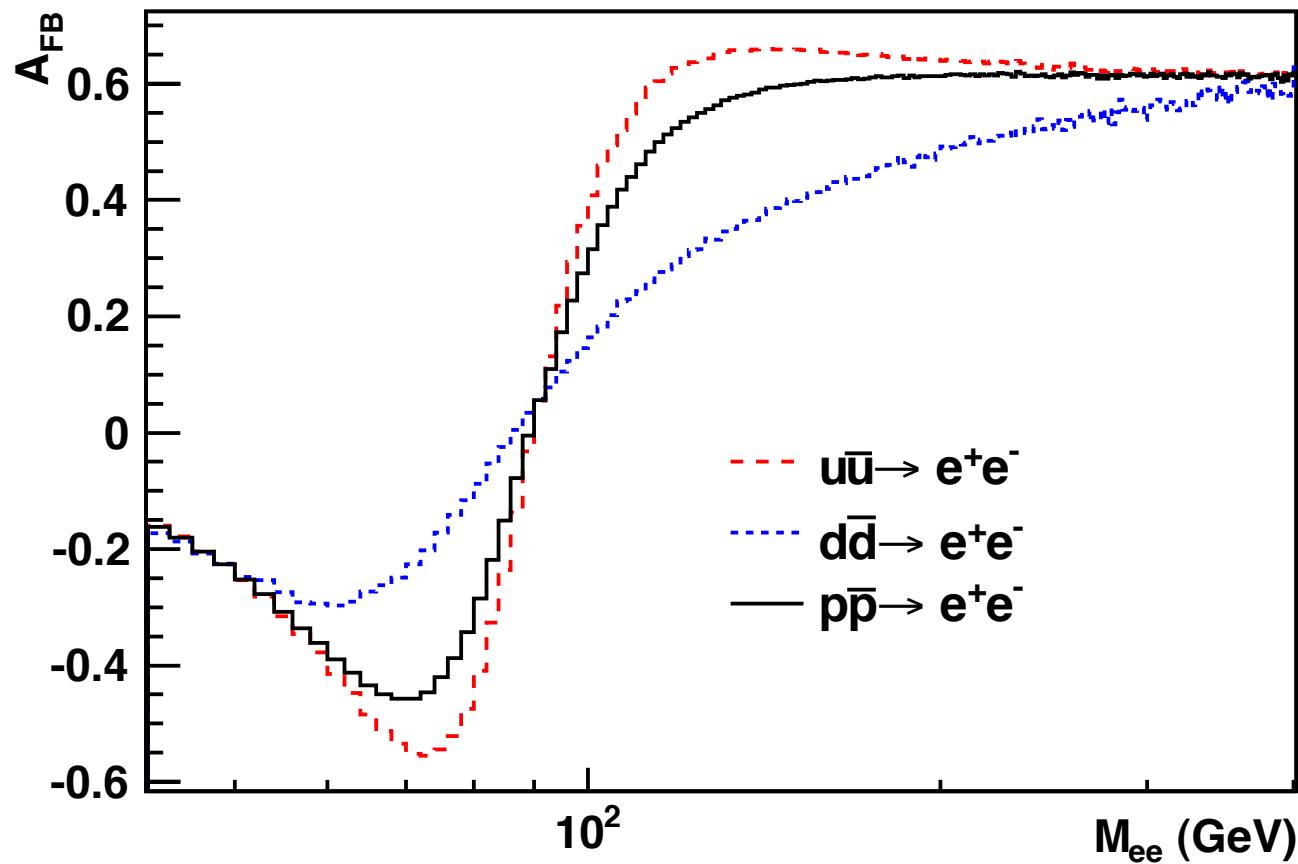
- Measured A_{FB} with 5.0 fb^{-1} DØ data collected at the Tevatron (2 TeV), to be submitted into PRD soon
- Unfolded data A_{FB} agrees with LO and NLO predictions
- Measured $\sin^2\theta_{\text{eff}}^{\text{lept}} = 0.2309 \pm 0.0008 \pm 0.0006$
 - Precision is better than the uncertainty of LEP(HAD combination), still dominated by statistical uncertainty
 - Results agree with Global EW fit
- Extract the *Z to light quark* couplings
 - world's most precise measurement of these couplings
- For weak mixing angle, with $8\text{-}10 \text{ fb}^{-1}$ combine both electron and muon channel with CDF, the expected precision will be comparable with world average

BACKUP

Collin-Soper



u/d A_{FB}



F/B efficiency difference

